UNPUBLISHED
RESEARCH
REPORTS

INTERMOUNTAIN STATION
Central Reference File
No. 3,411

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH ADMINISTRATION
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

NOT FOR PUBLICATION
FOR ADMINISTRATIVE USE ONLY

Information Concerning Tree Killing Forest Insects of the Northern Rocky Mountain Region

By
Forest Insect Laboratory
Coeur d'Alene, Idaho

FILE COPY
MISSOULA
FOREST INSECT
LABORATORY

INDEX

Subject	Page Number
Introduction	1
Important Bark Beetles	2
The Mountain Pine Beetle	4
Western Pine Beetle	5
Douglas Fir Beetle	6
Engelmann Spruce Beetle	7
The Lodgepole Pine Beetle	7
Red Turpentine Beetle	8
Secondary Bark Beetles	9
Oregon Pine Engraver	9
The Vancouver Ips	10
The Fir Engraver	10
Western Balsam Bark Beetle	10
Forest Defoliating Insects	11
Spruce Budworm	12
Douglas Fir Tussock Moth	13
Pine Butterfly	14
Hemlock Looper	14
Larch Sawfly	15
Lodgepole Sawfly	16
Terms Used in Discussing Bark Beetles	17
Terms Used in Discussing Forest Defoliators	20

Information Concerning
Tree Killing Forest Insects
of the
Northern Rocky Mountain Region

by
Forest Insect Laboratory
Coeur d'Alene, Idaho

Many different species of insects feed on forest trees. Fortunately only a few are responsible for the killing of commercial timber. These losses occur in almost all forested areas, but vary greatly in their severity. They may occur as scattered trees killed by bark beetles, and amounting to only a fraction of a tree per acre. Or epidemics may develop that over a period of years will result in the death of a large percent of the timber stand on large areas.

Timber losses must not be measured by their stumpage values alone. The relation of such losses to the industrial economy of the region, and their effects upon planned forestry programs are factors that must be considered in appraising the importance of insect damage. These factors makes the insect problem an essential and vital part of forest management.

Destructive forest insects are not new to the forests of our nation. Many of them have always been present, and no doubt will always remain, but it is hoped in a much lesser degree of importance. Forest insect control is difficult and expensive. The eradication of insects that are native to a region is practically impossible. However, proper forest practices will hold insect populations to levels that losses of valuable timber as a result of insect attack will be reduced to a minimum.

Forest tree killing insects are, for convenience of discussion, often placed in two rather rough classifications. These are called "bark beetles", and "defoliators". This circular includes discussion of the important forest insects of this region that are in these two classifications. It is hoped that these discussions are in sufficient detail to permit these insects and their destructive work, to be readily recognized.

A glossary of terms and words used in the discussion of insect infestations has been included as a part of this circular. Its use will clarify the meaning of doubtful terms and expressions, and eliminate the necessity for constant repetition of explanations in the discussion of each insect.

This circular compiled from available information by James C. Evenden.

IMPORTANT BARK BEETLES

Many different species of bark beetles attack all species of forest trees. Of these many species those belonging to the Genus Dendroctonus (Killer of Trees) are of the greatest importance. These few species of bark beetles attack and kill trees by constructing galleries or tunnels between the bark and wood. These galleries form a distinct pattern that can be associated with each bark beetle species, and is a positive identification of it. Each bark beetle has its own list of host trees, and although in rare instances it attacks other tree species, such attacks are seldom successful.

In addition to the Dendroctonus beetles there are a few other species, usually considered as of secondary importance, that some times assumes a tree killing role. Under conditions favorable for their development, aggressive populations develop that for a period of time healthy trees are attacked and killed. Fortunately such outbreaks are of short duration. In considering all phases of the bark beetle problem there are many questions to be asked concerning the habits and behavior of these beetles. An attempt has been made to anticipate the most important of these in the following questions and answers.

How many beetles or individual attacks are required to kill a tree?

The number of beetles, or individual attacks required to kill a healthy tree will vary with its size and resistance. Resistance to bark beetle attack is the vigor or health of a tree. Under normal conditions there are from 8 - 12 individual attacks per square foot of bark surface. These attacks may extend from the ground to an 8 inch top diameter of the bole.

How many beetles emerge from an infested tree?

In each egg gallery there are from 60 to 80 eggs. As with Dendroctonus beetles there are an equal number of males and females. The eggs from one gallery could produce from 30 to 40 pairs of beetles, making an increase in the beetle population of 1 to 30 or 40. Fortunately such increases do not occur. There is a normal mortality in the developing broods of bark beetles, that amounts to 90 percent or more. This mortality is caused by parasitic insects, woodpeckers, disease, abnormal weather conditions, and a flight mortality between the time the beetles emerge and their subsequent attack. As a result the annual increase in bark beetle populations is seldom more than 300 percent. However, the females of most Dendroctonus species make two attacks. After the first egg gallery has been completed and eggs deposited, the females emerge and make a second attack in another tree. From 30 to 40 days are required to complete the first attack. This event in the life history or development of these beetles is called "parent adult emergence". These dual attacks add to the population potential, and complicate the seasonal history.

Will we always have bark beetle infestation?

Bark beetles that are native to this country will perhaps always be present in our mature forests. Their importance will vary with different forest conditions. When the environmental factors of a forested area are in proper balance bark beetle populations are held at a normal or low endemic infestation level. Under such conditions their attacks are confined to trees of low vigor and to windfalls. Unfortunately such ideal conditions can change rapidly and destructive beetle outbreaks develop in a few years. These changes follow the failure of one or more of the natural forces that have aided in maintaining a previously balanced condition. Some of the most important of these forces would be tree resistance to insect attack, unfavorable climatic condition, the activity of natural enemies, and the occurrence of abnormal accumulations of favored host material. So although we can expect bark beetles, that are native to this country to be present within our forests, we should not anticipate the continued existence of destructive epidemics.

Can bark beetle epidemics or outbreaks be prevented?

As long as there are unmanaged stands of mature timber there exists a potential danger of bark beetle outbreaks. By artificial control the frequency and severity of these outbreaks can be minimized but not prevented. Forestry looks to the prevention of bark beetle outbreaks rather than to their control. As forested areas are placed under sound management, most timber stands can be kept in a healthy condition, that is resistant to beetle attack. Until such management is achieved areas of mature timber must be watched carefully and control measures initiated whenever needed. Good management will be a long step in preventing bark beetle epidemics.

Can a tree be saved after it has been successfully attacked?

When a tree has been successfully attacked by bark beetles its life cannot be saved. Although the foliage may remain green for months its death is assured.

If infested trees cannot be saved of what benefit is control?

Artificial control destroys bark beetle broods developing beneath the bark of infested trees, and prevents their emergence and subsequent attack of other trees.

How can infested trees be recognized?

Trees attacked by Dendroctonus beetles can be recognized by fresh pitch (Pitch Tubes) accumulations on the surface of the bark, around or below the entrance to the egg galleries; (2) by boring dust around the base of trees or in bark crevices; and (3) by discolored foliage in May and June

following the previous season's attack. When trees are heavily attacked the flow of pitch is quite light and often absent. These are called "blind attacks". With Douglas fir there is no flow of pitch associated with a bark beetle attack. Large pitch tubes are usually an indication of a pitched out attack. With pitched out attacks there is very little and sometimes no boring dust. Fresh woodpecker work on the tree trunk is an indication that there were and probably are beetle broods beneath the bark. To be sure that a tree is not infested it must be examined carefully for the presence of boring dust.

To identify the attacks of tree killing bark beetles one must be familiar with their gallery or work pattern. Egg galleries of Dendroctonus beetles are packed with boring dust, while those of other species are open. This is the first step in the identification of Dendroctonus beetles. It is nearly always necessary to remove a piece of bark to identify the attacking beetle. Larval mines must be traced back to the egg gallery to be sure of their identity.

Some trees are attacked on one side only. In most instances these will be "pitched out" attacks. Occasionally these one sided attacks will be successful and broods of insects will be produced, but the trees will not be killed. When the trees are badly weakened the green side is usually attacked the following season - sometimes by secondary beetles.

Dendroctonus Beetles of the Northern Rocky Mountains and their Host Trees

Common Names	Technical Name	Hosts
Western Pine Beetle	Dendroctonus brevicomis Lec.	Ponderosa Pine
Mountain Pine Beetle	Dendroctonus monticolae Hopk.	Western white pine Lodgepole pine Ponderosa pine White bark pine Limber pine, and sometimes Engelmann spruce.
Douglas Fir Beetle	Dendroctonus pseudotsugae Hopk.	Douglas fir
Engelmann Spruce Beetle	Dendroctonus engelmanni Hopk.	Engelmann spruce
Lodgepole Pine Beetle	Dendroctonus murrayanae Hopk.	Lodgepole pine
Red Turpentine Beetle	Dendroctonus valens Lec.	All pines

THE MOUNTAIN PINE BEETLE, Dendroctonus monticolae Hopk.

The mountain pine beetle is found throughout the States of Oregon, Washington, California, western Nevada, Idaho, western Montana, and northwestern Wyoming. It attacks and kills western white pine, lodgepole pine, ponderosa

pine, white bark pine, limber pine, sugar pine, and sometimes Engelmann spruce when this tree species occurs in association with a pine infestation.

Adult mountain pine beetles are black, cylindrical in shape, slightly less than 1/4 of an inch in length, and not quite as big around as a wooden match. Trees are attacked by the female beetles boring through the bark and excavating egg galleries between the bark and the wood. At the bottom of these galleries, which extend up the tree and along the grain of the wood, there is usually a short crook. In standing trees the gallery length will vary from 12 to 18 inches, but in windfalls or logs they are often 30 or more inches in length. There are from 6 to 12 individual attacks or galleries per square foot of bark surface. Egg galleries of the mountain pine beetle are always packed with boring dust.

Attacks of the mountain pine beetle are recognized by pitch tubes and boring dust on bark flakes and around the base of the tree.

As the egg gallery is constructed, tiny eggs are laid in small nitches along its sides. These eggs hatch in a week or ten days into small white legless grubs (larvae). These grubs feed upon the inner bark, constructing individual feeding tunnels (larval mines) at right angles to the egg gallery and from one to three inches in length. Egg galleries and feeding tunnels are exposed on the inner surface of the bark.

When full grown the larvae construct small cells at the end of their feeding tunnels in which they transform to adult beetles. This transformation from larva to adult beetle, is called the pupal stage; and the cell a pupal cell. Normally there is but one generation of this beetle each year, but an overlapping of broods complicates the seasonal history. Broods of the mountain pine beetle overwinter as parent adults, new adults, and small to mature larvae. The overwintering new and parent adults emerge in June and attack new trees. The overwintering larvae mature and emerge as new adults and attack in late July. New adults that attacked in June emerge in late July to make their second and final attack as parent adults. The broods of beetles that develop from these different attack periods emerge as new adults approximately one year later. All stages of mountain pine beetle brood development are found during the summer season.

WESTERN PINE BEETLE, Dendroctonus brevicomis Lec.

The western pine beetle attacks ponderosa and Coulter pine within the range of these trees in California, Oregon, Washington, Idaho, Montana and western Canada. Under normal conditions it attacks over-mature trees of low vigor. But when epidemic conditions occur healthy, vigorous trees of all age classes are attacked and killed. Trees infested with the western pine beetle are recognized by pitch tubes and boring dust. Trees under 6" in diameter are seldom attacked by this beetle.

The adults are brown cylindrical beetles about 1/5 of an inch in length. The females bore through the bark and construct winding egg galleries that are packed with boring dust. These galleries cross and recross in an irregular manner, forming a network of irregular markings on the inner

surface of the bark. This egg gallery pattern is peculiar to this beetle in this region and a positive identification of it. Eggs are laid along these galleries, which in 10 days or more, hatch into small, white, legless larvae. There are no exposed larval mines as the development of the larvae occurs within the inner bark. To locate western pine beetle larvae the bark must be shaved at right angles to the axis of the tree. When mature each beetle cuts an emergence hole through the outer bark. There are 1 to 2 generations of the western pine beetle in the northern portion of its range, and from 2 1/2 to 4 in the southern portion.

DOUGLAS FIR BEETLE, Dendroctonus pseudotsugae Hopk.

The Douglas fir beetle is found throughout the range of Douglas fir in western United States and Canada. It attacks and kills healthy, mature Douglas fir, and is sometimes found in western larch logs and windfalls.

The adult beetles are stout, reddish to blackish brown, cylindrical bark beetles about 3/10 of an inch in length. The females construct rather straight, perpendicular egg galleries between the bark and wood, that are from 8 to 16 inches in length and packed with boring dust. Eggs are placed in alternate groups along the sides. These eggs soon hatch into small, white, legless larvae which feed upon the inner layers of bark. During their development the larvae construct rather long feeding tunnels at right angles to the egg gallery. However, during the final stages of larval development many larval mines and pupal cells are concealed in the inner bark. Newly formed adults often congregate beneath the bark for a week or more prior to emergence. There are from 7 to 10 or more individual attacks of this beetle per square foot of bark surface.

During normal seasons there is but one generation of this beetle each year. However, there are two distinct attack periods, which makes a complicated seasonal history. Females will attack one tree, construct an egg gallery, lay eggs, and some 30 days later, or with the July attacks, the following May, emerge and make their second attack. Broods of this beetle pass the winter as larvae, new adults and parent adults that were attacked the previous season.

The first attacks are made in May by overwintering new and parent adults. Broods from the May attacks complete their development and pass the winter as new adults. The second attacks are made in July by the overwintering larvae that have developed to adult beetles, and by the re-emerged new adults that overwintered and made their first attack in May.

Attacks of the Douglas fir beetle are located by reddish boring dust around the base of trees or in bark crevices. There are no pitch tubes on Douglas-fir. As a result in searching for infested trees, every tree must be carefully examined. Foliage discoloration is so variable and uncertain that it is of little value in locating infested trees. Boring dust is the only positive indication.

ENGELMANN SPRUCE BEETLE, Dendroctonus engelmanni Hopk.

The Engelmann spruce beetle attacks and kills Engelmann spruce throughout the Rocky Mountain region. It also attacks other species of spruce within its range which includes Oregon, Washington, Idaho, Montana, Wyoming, South Dakota, Utah, Colorado, Arizona and New Mexico. Large overmature trees are preferred hosts, however, during epidemic outbreaks there is no apparent selection of low vigor trees. Under such conditions all spruce trees within the stand, regardless of age or vigor, above 8 or 10 inches in diameter are often attacked and killed.

Adult Engelmann spruce beetles are about one-fourth of an inch in length. They are cylindrical in shape, and reddish brown in color. New adults often show a lighter shade of brown on their wing covers. The females construct short, nearly straight, perpendicular egg galleries in the inner bark that slightly score the wood. These galleries are wider than the beetles, and although packed with boring dust, an open passageway through the center is maintained. Eggs are laid side by side in elongated cells, on opposite sides. Upon hatching the small larvae feed as a group through the inner bark away from the egg gallery, which results in a feeding chamber or cell. As they increase in size individual feeding tunnels are constructed. Transformation to adult beetles takes place in pupal cells at the end of the individual feeding tunnels. These cells are usually exposed on the inner surface of the bark, but in thick barked trees they are sometimes concealed.

The seasonal or life history of the Engelmann spruce beetle is quite complicated. Adult beetles often emerge and hibernate through a second winter at the base of trees attacked the previous season. Dates of emergence of new broods and their subsequent attack of other trees will vary for different elevations and exposures. These habits make it necessary to determine for each situation the existing status of development of the insect broods at the time of examination. However, the periods of heaviest attack are during July and early August.

New attacks of this beetle are difficult to find. Pitch tubes are difficult to see, and sometimes absent. As attacks are often initiated and confined to the upper portion of the bole, there are no marked accumulations of boring dust at the base of infested trees. There are instances when a bit of boring dust on the leaves of underbrush is the only visible evidence of attack. As the foliage of beetle infested spruce falls soon after it starts to fade, there are no "red topped" spruce trees to serve as an indication of infested areas.

THE LODGEPOLE PINE BEETLE, Dendroctonus murrayanae Hopk.

The lodgepole pine beetle confines its attacks to lodgepole pine in eastern Washington, Idaho, Montana, Wyoming, and Colorado. It is of no great importance, although under favorable conditions for its development it kills large overmature trees. Its attacks are often mistaken for those of the mountain pine beetle and some confusion in the identification of these beetles can result.

Adult beetles are stout, cylindrical bark beetles about one-fourth of an inch in length. Their elytra (wing covers) are of a reddish brown, with the prothorax and head a dark brown or black. They are quite distinctly two-toned in color.

Attacks are made by the female beetles boring through the bark and constructing short, nearly perpendicular egg galleries between the bark and wood. These galleries vary from 5 - 10 inches in length, and although packed with boring dust, there is an open passageway or channel through the center. Eggs, separated from each other by packed boring dust, are laid along one side of this gallery. In feeding the larvae work away from the egg gallery as a group, producing a common feeding, or brood chamber. At no time in their development do the larvae construct individual feeding tunnels. Transformation to adult beetles takes place in pupal cells constructed in the excrement of the chamber, or in the inner bark along its margin. The seasonal history of this beetle is not thoroughly understood, but it is assumed that there is but one generation each year.

Attacks of the lodgepole pine beetle are easily recognized by the large pitch tubes, an inch or more in diameter, at the base of the tree. There may be 5 or 6, or as many as 25 or more of these tubes around the base of an attacked tree. The attack seldom reaches to a height of more than 4 or 5 feet. Trees are often attacked for three or four successive years before their resistance is so reduced that the upper bole is attacked by other bark beetles. In some instances trees are killed by heavy basal attacks alone, while other attacked trees live indefinitely. Destructive populations of this beetle develop rapidly in freshly cut stumps. These aggressive populations often kill large, overmature lodgepole pine that are left during logging operations.

RED TURPENTINE BEETLE, Dendroctonus valens Lec.

The red turpentine beetle attacks the base of injured, dying, and often apparently healthy trees, freshly cut logs and stumps of all species of pine, and some times larch, spruce and fir. Attacked trees usually show some previous injury, although healthy trees are sometimes attacked, but seldom killed. Freshly cut stumps on ponderosa pine cuttings contribute to the building of destructive turpentine beetle populations.

Adult red turpentine beetles are the largest of all North American bark beetles. They are from 1/4 to 3/8 of an inch in length, stout, cylindrical, and of a uniform reddish brown in color. Attacking beetles excavate somewhat irregular, longitudinal or diagonal egg galleries that are from a few inches to a foot or more in length. These galleries, wider than the beetles, are packed with boring dust. Eggs are laid in groups or masses along the sides which hatch into stout, yellowish white larvae that are larger than those of other western bark beetles. During their development the larvae feed between the bark and wood in a common brood, or feeding chamber. These chambers vary from a few square inches to a foot or more in area, and are often filled with a resinous liquid. Transformation to adults takes place within pupal cells constructed in the boring dust of the brood chamber, or in short mines around its margin.

Trees infested with this beetle are easily recognized by the large pitch tubes that form at the point of attack. Attacks are confined to the base of the tree, and are seldom more than 4 or 5 feet from the ground. There is but one generation of this beetle each year, although in some instances there may be a partial second during long seasons. Broods of these beetles pass the winter as larvae, new adults and parent adults, in trees and stumps attacked the previous season.

SECONDARY BARK BEETLES

Many species of bark beetles are of secondary importance as they attack injured and dying trees. However, under favorable conditions for their development, some species develop aggressive populations that for short periods become primary in their attacks of living trees. The most important of these so called secondary beetles are discussed briefly in this circular, in order that they may be recognized.

OREGON PINE ENGRAVER, Ips oregoni Eichh.

The Oregon pine engraver is found throughout the Western United States. It attacks windfalls, freshly cut logs, and slash of all species of pine, and quite often the tops of mature pine trees. Under favorable conditions for its development, usually an ample supply of attractive host material, populations develop that for a short time living trees are attacked and killed. Such outbreaks are often destructive but in most instances by the time the situation is reported the danger of further loss has passed.

Adults of the Oregon pine engraver are reddish brown to nearly black beetles, about 1/6 of an inch in length. They are easily separated from Dendroctonus beetles, by the declivity at the posterior end of their wing covers. With Dendroctonus beetles the posterior end of the elytra, or wing covers, is smooth and rounded, but with Ips beetles there is a distinct declivity. The margins of this declivity are armed with teeth or spines, and as their number and shape are peculiar to each Ips species, they are a positive means of identification.

The work or gallery pattern of the Oregon pine engraver shows 3 or 4 egg galleries extending up and down the tree from a nuptial or central chamber. These galleries are from 5-10 inches in length and follow the grain of the wood rather closely. There may be from 1 to 7 females to each male with as many egg galleries radiating from the central chamber. Eggs are laid along both sides of these galleries, which soon hatch into small, white, larvae. Pupation occurs in small cells constructed in the inner bark by the mature larvae. Egg galleries of this and other Ips sp. are always free of boring dust.

In this region there are from 2 to 4 generations of this beetle each year, depending upon the length of the season. Each female also makes two attacks. The multiple generations, with the emergence and reattack of the parent

beetles, results in overlapping attacks with broods in all stages of development throughout the season. The potential power of this insect to develop large destructive populations is quite apparent. Boring dust is the primary evidence of attack.

THE VANCOUVER IPS, Ips vancouveri Sw.

Attacks of the Vancouver ips in white pine logs and windfalls can be confused with those of the mountain pine beetle. The adults of this species are about 1/4 of an inch in length, reddish brown to black in color, but with a distinct elytral declivity at the posterior end of the wing covers.

The gallery pattern is somewhat similar to the Oregon engraver beetle. There are from 3 to 5 egg galleries extending up and down the tree from the nuptial chamber. An individual egg gallery and its associated larval mines of this beetle, is quite similar to one made by the mountain pine beetle. However, the egg galleries of the Vancouver ips are always free of boring dust and radiate from a central chamber. Egg galleries of the mountain pine beetle are individual galleries and are packed with boring dust. The Vancouver ips only attacks white pine logs and windfalls. Boring dust is the only evidence of attack.

THE FIR ENGRAVER, Scolytus ventralis Lec.

The fir engraver beetle is found throughout the western United States. It attacks true fir only. Adults are short, black bark beetles about 1/8 of an inch in length. They have a distinct ventral declivity at the posterior end of the body under the wing covers.

The work pattern of this beetle is distinct and peculiar to this one species. It consists of two egg galleries, extending across the grain of the wood on both sides of a central or nuptial chamber. Each gallery is from 2 to 6 inches in length, and scores both the inner surface of the bark and the wood rather deeply. Eggs are laid in niches along the top and bottom sides of each gallery, and the larvae work up and down the tree in individual larval mines for distances of 5 - 6 inches. When mature the larvae transform to new adult beetles in pupal cells constructed at the end of the larval mines.

WESTERN BALSAM BARK BEETLE, Dryocoetes confusus SW

The western balsam bark beetle is found throughout the northwestern United States and adjacent Canadian areas. It attacks and kills alpine fir, and some times other species of fir and spruce. In some areas it has been quite destructive. The adults are small, reddish brown bark beetles about 1/8 inch in length. Their work pattern consists of a small, nuptial chamber in the inner bark, from which several egg galleries radiate. Eggs are laid along both sides of these galleries. There is apparently but one generation each year.

FOREST DEFOLIATING INSECTS

Forest defoliators are those species of insects that during their caterpillar or larval stages of development, feed on the foliage of forest trees. Under normal conditions these forest enemies are held at low population levels by natural forces of control. At times these natural forces fail, and epidemic populations of the destructive insect occur. This development is often so rapid that large areas of timber may be severely defoliated before the seriousness of the outbreak is realized.

The effects of defoliation vary for different tree species, and often times for the same species under different forest conditions. Deciduous trees will endure several years of severe defoliation. Western larch, alders, and willows have been known to produce a second coverage of foliage the same year of severe defoliation. On the other hand one seasons complete defoliation will kill most evergreen trees. Although most defoliator outbreaks are of rather short duration, serious timber losses often occur.

Until recent years the direct control of forest defoliating insects on large areas was impractical. Although it was only necessary to apply a poisonous spray to the foliage of infested trees, the application of the spray was not simple. Sprays were successfully applied from the ground for the control of defoliating insects on forest trees in camp grounds and along road sides. However, the ground spraying of large, rough, mountainous areas, was economically prohibitive. The airplane was considered as the only solution to this problem and for years this seemed far distant. Airplanes were used as long ago as 1921 to apply poisonous dusts and sprays to small forested areas, but these tests offered no economic solution at that time.

Recent developments of new insecticides, and the use of improved aircraft as a means of dispersal, now make the control of these insects a reality. Although dosages as low as one gallon of spray per acre have been successfully applied from the air, to control forest defoliators, it is still an expensive operation. Every effort must be made to conduct control at a time when the greatest benefits will be derived from minimum expenditures.

Important Forest Defoliators of the Northern Rocky Mountains and their Host Trees

Many insects feed on the foliage of forest trees and shrubs. Fortunately only a few species are of economic importance in this region. These are shown in the following tabulation and a description of each species follows.

Common Name	Technical Name	Host Trees
Spruce Budworm	Archips funiferana Clem.	Douglas fir and true fir preferred. Spruce and other species second choice.
Douglas Fir Tussock Moth	Hemerocampa pseudotsugata McD.	Douglas fir preferred. Other species second choice.
Pine Butterfly	Neophasia menapia Feld.	Ponderosa pine preferred.
Hemlock Looper	Ellopia fiscellaria lugubrosa Guen.	True fir and hemlock preferred. Other trees second choice.
Larch Sawfly	Pristiphora erichsonii Htg.	Western larch.
Lodgepole Sawfly	Neodiprion burkei Midd.	Lodgepole pine.

SPRUCE BUDWORM, Archips funiferana Clem.

The spruce budworm is found throughout the northern United States and Canada. In this region its preferred host trees are Douglas fir and white fir. Spruce, hemlock, and other evergreen trees are attacked when in association with the preferred hosts, and outbreaks have occurred in pure lodgepole pine stands.

Adults of the spruce budworm are small, mottled, brownish moths, with a wing expanse of about an inch, but with no distinctive wing markings. The moths appear in August and lay inconspicuous masses of light, green eggs, on the underside of needles. The eggs hatch in 10 or 12 days and the small larvae construct cocoons under flakes of bark and in other sheltered places. These are called hibernacula and are most difficult to find. In the spring the still tiny larvae, emerge from their overwintering shelters and bore into and feed on the fleshy inside of the previous seasons needles. When about one-eighth of an inch or more in length, the larvae leave the needles and bore into the new growth buds as they start to swell. As the buds open the larvae constructs semi-nests, by binding some of the new needles together with silken threads. The new growth is the preferred food and the larvae will practically starve before eating old foliage. During severe epidemics nearly all of the new growth twigs are left bare of needles. When disturbed the feeding larvae will drop from their so-called nests and hang by a silken thread.

When full grown, budworm larvae are about an inch in length, deep brown in color, with yellowish pale green markings, and numerous wart like (tubercles) growths along the sides. They reach maturity in late July, and pupation takes place in a rigid case (chrysalis or obtect pupa) among the webbed needles or attached to limbs and twigs. Adult moths appear some two weeks later, eggs are laid and the one generation per year completed.

Spruce budworm infestations are rather easily recognized during the same season of attack, even though the insects may not be present. The empty brown pupal cases which will be found hanging to the defoliated twigs, with the webbed needles, is good evidence of budworm activity. During July and August or until heavy rains occur, the dead needles clinging to the defoliated limb tips give to the infested trees a scorched appearance peculiar to budworm infestation.

DOUGLAS FIR TUSSOCK MOTH, Hemerocampa pseudotsugata McD.

The Douglas-fir tussock moth attacks Douglas fir throughout the northwestern United States. Although Douglas fir is the preferred host, other tree species growing in association with it are attacked during epidemics.

Adult moths appear the latter part of August and are present throughout most of September. Female moths are wingless, having but two short, rudimentary stumps of wings. Their bodies are from ½ to 5/8 of an inch or more in length, and covered with a mat of dark grey hairs. Their abdomens are packed with eggs which are laid soon after emergence in a mass on top of the cocoons from which they emerged. The eggs are round, 1/25 of an inch in diameter, and there are from 75 to 125 or more of them in each egg mass. These masses are covered with a frothy, gelatinous secretion in which are embedded hairs from the body of the female. The eggs overwinter and hatch the following late May and early June.

Adult males have well developed wings which are from 1 to 1-1/4 inches in width when expanded. The fore-wings are dark, greyish chocolate brown on the upper side, with two irregular dark transverse bands. There are also small, white, irregular markings on the upper side of the fore-wings. Hind wings and the under side of the fore-wings are a light uniform rusty brown with darker marginal shadings.

Tussock moth caterpillars are handsome creatures, if caterpillars can be handsome, as they are decorated with brightly colored tufts of hair. When full grown they are from 3/4 to 1¼ inches in length. There are two tufts of black hair directly behind the head with a single shorter tuft at the posterior end. The body is marked with short tufts of hair and numerous red spots, with two light colored lateral stripes along the side. There are two distinct body colors, one a light fawn, the other greyish. The fawn colored ones are somewhat larger and it is thought that they may be females, but this point has not been established.

Caterpillars mature during August and construct cocoons in which they transform to adult moths. The cocoons are thin, tough textured, made of silk and hairs from the body of the caterpillar. When the cocoon is constructed the caterpillar is quite naked, being devoid of all hairs. Cocoons are attached to all parts of trees, underbrush, fences, houses, etc. Adults appear some 10 days later and the one generation per year is completed.

The fact that female moths are wingless does not prevent the spread of infestations of this insect. When disturbed the newly hatched caterpillars

drop and hang suspended from the limbs on fine silk threads. These threads, with the body hairs of the tiny caterpillars offers considerable wind resistance, and they are apparently carried considerable distances by air currents of 10 miles or more per hour.

As the wingless females lay their eggs on the previously defoliated trees, a concentration of feeding caterpillars occurs which results in severe 100 percent defoliation. It is this concentrated attack that makes this insect the most destructive defoliator of the region. The felt like cocoons are a positive means of identifying infestations of this insect.

PINE BUTTERFLY, Neophasia menapia Felder

The pine butterfly attacks ponderosa pine, white pine, and lodgepole pine in the Northwestern United States. However, the only serious outbreaks of this insect has been in ponderosa pine.

The adults have a wing expanse of 1-3/4 inches and closely resembles the common cabbage butterfly so often seen around gardens and along road sides. Antennae are black, the head and body black above, and white beneath. The wings of the male are white with black margins along the tips that are not so heavy on the hind wings. Wings of the female have a distinct yellowish cast with the same black margins. With some females there are bright orange spots along the apical margin of the hind wing.

In this region there is but one generation of this butterfly each year. Eggs are laid in late July and early August. They are deposited on pine needles in two parallel rows of 5 to 20 eggs. These rows are cemented together and the eggs point at an angle of 45 degrees toward the end of the needle.

The eggs hatch the following June. The larvae are small, about 1/10 of an inch in length; the body a pale green and the head a shiny black. When mature they are about one inch in length, dark green in color with a pale green head, and two white lateral stripes along each side.

Newly hatched larvae develop slowly and for the first two weeks feed in clusters, encircling a needle, with their heads a shiny ring of black beads, pointing toward the needle tip. Later in their development this habit of feeding is discontinued. When mature the larvae, or caterpillars lower themselves from the trees to the ground by silken threads, sometimes 75 feet or more in length. Transformation from the caterpillar to the adult butterfly takes place as a chrysalid attached to shrubs, grasses, limbs, tree trunks, etc. - apparently the first place encountered. Some 15 or 20 days later the butterflies emerge, eggs are laid, and the one generation per year is completed.

HEMLOCK LOOPER, Ellopia fiscellaria lugubrosa Guen.

The hemlock looper attacks hemlock, true firs, and spruce along the northern United States and Canada. During epidemic outbreaks other tree species are attacked, although hemlock and fir are the preferred hosts.

Adults are light, brown moths, with the forewings marked with two wavy transverse lines and the hind wings with one line. They have a wing expanse of 1½ inches. Eggs are laid in September which hatch the following spring. The eggs are small, 1/16 of an inch in diameter, and are attached to moss on the tree trunks and other sheltered places on the twigs and branches. The newly hatched larvae are about 1/4 of an inch in length, but when mature are 1½ inches long. They are green to brown with diamond-shaped markings on their backs. They are known as loopers or "measuring worms", a name derived from their mode of travel. The caterpillars mature in August and transform to moths in unprotected greenish brown chrysalids that are attached to different parts of the tree. The moths appear in late August and early September, eggs are laid, and the one annual generation is complete.

During severe outbreaks of this defoliator the moths occur in such numbers as to dam small streams and creeks, and clouds of them appear when the trees on which they are resting are disturbed. In moving about on the severely defoliated trees the caterpillars drop on silken threads. These threads are often so abundant that trees are enclosed in shrouds, and entire timber stands look like big cobwebs.

LARCH SAWFLY, Pristiphora erichsonii Htg.

The larch sawfly, for years considered as an insect of the northeastern United States, was recorded on the Flathead National Forest in 1934. It is not known if this outbreak originated from some eastern locality, or if the insect is native to this region. However, during subsequent years the infestation spread throughout the larch forests of western Montana and northern Idaho. This outbreak continued until 1944, but with no records of timber losses.

Sawflies belong to the same order of insects as bees and wasps. The adults are inconspicuous, black, fly like insects, about 1/3 of an inch in length, with a light brown band around their body. The females have a sawlike appendage on the tip of their abdomen with which they cut holes in the current twig growth in which single eggs are deposited.

The larvae are about 3/4 of an inch in length. The head is black, and the body color is light green on the under side and a darker green above. These two body colors are separated by a distinct line and there is a faint dark line down the center of the back.

Eggs are laid in notches cut along one side of the new growth tips of the previous season's growth. This injury causes the tips to curve slightly and is a positive indication that the insects are present. Eggs are laid in the spring of the year, which hatch soon after the larch foliage appears. The larvae develop rapidly and are full grown in July. When mature they drop to the ground and construct a thin parchment like cocoon in which they pass the winter. In the spring they transform to the adult form, eggs are laid, and the one generation per year is complete.

As larch is a deciduous conifer, shedding its foliage each year, it is resistant to attacks by defoliating insects.

LODGEPOLE SAWFLY, Neodiprion burkei Midd.

Adult lodgepole pine sawflies are small wasp-like insects about 1/3 of an inch in length. The caterpillars are greenish or greyish green in color with light stripes along the sides and back. The head is dark brown and the eyes are black. When full grown the caterpillars are about an inch in length.

Eggs are laid in late June and early July, in notches cut in the edge of lodgepole pine needles. The eggs hatch in about 30 days and the larvae are usually full grown by the 1st of September. When mature they drop to the ground, and spin tough brownish parchment-like cocoons under the old needles or other sheltered places in which they remain as larvae until the following spring, when they transform to adults. Soon after the adults emerge, eggs are laid which starts the one generation per season.

TERMS USED IN DISCUSSING BARK BEETLES

This glossary or explanation of terms and words commonly used in discussing forest insect infestations saves repetition in the discussion of the different species,

Attack. An explanation of the word attack depends on how it is used. An individual attack would mean the attack of one pair of beetles. An attacked tree would involve all of the beetles attacking and could be a light or heavy attack.

Adult. An insect sexually mature and ready to reproduce normally.

Adults, new. Newly formed adults before their emergence. New adults are often light brown in color.

Adults, parent. Adult beetles that have attacked and are producing a brood of beetles.

Beetle abandoned trees. Trees from which the destructive or primary beetles have emerged.

Black tops. Insect killed trees from which most of the foliage has fallen and that have been dead for 2 or more years.

Brood. All the specimens that hatch at about one time, from eggs laid by one series of parents and which normally mature at about the same time.

Boring dust. The fine dust made by attacking bark beetles as they bore through the bark. This dust falls to the base of the tree or is caught in bark crevices.

Dust. See boring dust.

Egg. The first stage of an insect.

Egg gallery. The gallery or tunnel between the bark and wood, along which eggs are deposited. Egg galleries of Dendroctonus beetles are packed with boring dust and frass.

Elytra. Hard shell-like wing covers of all beetles. The elytra cover the membraneous wings that are folded beneath.

Emergence hole. The hole in the bark through which the newly formed adult beetles emerge. These are small round holes scattered over the bark surface. With some species of bark beetles the parent adults will, after making one attack, emerge and make a second one. Parent adult emergence holes are found at the top of egg galleries, and need not be confused with those made by the emergence of the brood.

Entrance hole. The hole made by the attacking beetles as they bore through the bark. With Dendroctonus beetles these holes are made by the females and are always at the bottom of an egg gallery.

Fading tops. The first fading or noticeably "off color" of the foliage of infested trees.

Feeding tunnels. See Larval Mines.

Frass. As used in bark beetle terminology frass refers to bark and wood fibers with which egg galleries are packed.

Gallery. Tunnels or mines constructed between the bark and the wood by attacking beetles and feeding larvae.

Generation. See brood.

Grubs. Insect larvae.

Host trees. Each bark beetle has its own list of trees that it attacks. These are called Host Trees.

Host types. Timber stands or areas of host trees. Such trees must be of a size suitable for attack.

Hibernate. To pass the winter in a dormant condition.

Insect, primary. An insect capable of attacking and killing a healthy tree.

Insect, secondary. An insect which follows or is associated with a primary form, but which is incapable of attacking and killing trees by itself.

Larva. The second stage of insect development; comes from the egg, grows, and changes to a pupa. See grub.

Larval mines. Feeding tunnels or galleries of the larvae. These mines increase in width as the larvae become larger.

Mines. See gallery or tunnel.

Mature larva. Full grown (pre-pupal) larva prior to their transformation to new adults. Mature larvae are approximately the same size as the newly formed beetles.

Ova, Ovum. The eggs; an egg.

Oviposition. The act of depositing eggs.

Overwintering stage. Refers to the specific stage in the development of an insect in which it hibernates or passes the winter.

Overwintering broods. Relates to beetle broods in all stages of development which have or are passing the winter under the bark of infested trees.

Parent adult. See adult.

Parent adult emergence. After adult beetles have made one attack and constructed one egg gallery, their emergence and reattack of a second tree is called parent adult emergence.

Pitched out attack. Attacking bark beetles that have been repelled or washed from their egg galleries through the entrance holes by a noticeable flow of pitch. Pitched out attacks are usually marked by large pitch tubes. See pitch tubes.

Pitched in attacks. Although attacking beetles often overcome an excessive flow of pitch and are able to construct an egg gallery, it is so filled with pitch that the eggs are coated so heavily that they fail to hatch.

Pitch tubes. A mass of resin or pitch that forms on the surface of the bark at the mouth of bark beetle entrance holes. Small tubes usually indicate a heavy, successful attack, while large tubes are good evidence of a pitched out attack.

Primary Insects. See insects primary.

Prothorax. That portion or segment of the insect's body that bears the anterior legs but no wings.

Pupa. The stage in which larvae transform to adult beetles.

Pupal cell. The small chamber or pit, usually at the end of the larval mine, in which pupation takes place.

Pupation. The act of becoming a pupa, and of subsequent transformation to an adult beetle.

Red Tops. Refers to the dark red color of the foliage of beetle killed trees which occurs a few weeks before the emergence of the beetle broods.

Seasonal History. The time and occurrence of the different events in the development of an insect - eggs, larvae, and adults.

Secondary Insects. See insects secondary.

Tunnel. See galleries.

TERMS USED IN DISCUSSING FOREST DEFOLIATORS

Antenna-ae. Two jointed, sensory organs, one on each side of the head, commonly termed horns or feelers.

Apex. That part of any joint or segment opposite the base by which it is attached; that point of a wing furthest removed from its base.

Apical. At, near, or pertaining to the apex.

Adult. A sexually mature insect ready to reproduce.

Brood. All the insects that hatch at about one time, from eggs laid by one series of parents, and which normally mature at about the same time.

Chrysalis or id. The intermedial stage between larva and adult in butterflies; see pupa.

Chitin. Material forming the hard parts of an insects body.

Cocoon. A covering, composed partly or wholly of silk or other viscid fibre constructed by larva as a protection to the pupa.

Caterpillar. Term applied to the larvae of a moth or butterfly.

Egg. First stage of an insect.

Fibre. Thread-like structure of any tissue.

Hibernaculum. A tent or covering in which a larva hibernates.

Obtect. Wrapped in a hard covering.

Pupa. Intermediate stage between larva and adult; a pupa is obtect, when enclosed in a rigid case on which the members may or may not be outlined. It is liber, or free when there is no covering.

Pupation. The act of becoming a pupa, in transforming from larvae to adults.

Pupal-cases. The thicken larval skin which formed the pupa, and which is shed when the adult insect emerges.

Silk. Hardened salivary secretion of certain larvae, mainly those of moths and butterflies.

Viscid. Sticky; covered with a shiny, resinous or greasy matter.

Tubercle. Small chitinous buttons on the bodies of caterpillars.

MOUNTAIN PINE BEETLE

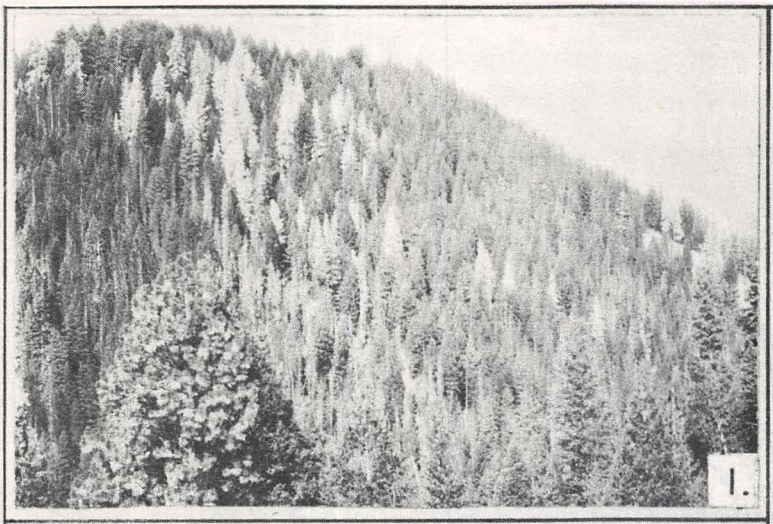
Dendroctonus monticolae Hopk.

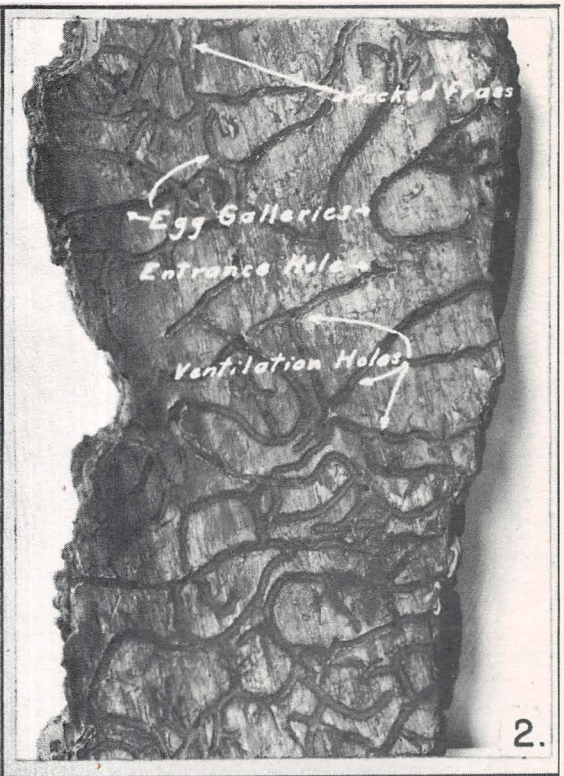
1. Pitch tubes on heavily attacked lodgepole pine.
2. Close-up of pitch tubes on bark.
3. Egg galleries and larval mines with young larvae.
4. Egg galleries, larval mines, pupal cells, pupae, and adults.

BE&PQ

WESTERN PINE BEETLE

Dendroctonus brevicomis Lec.


1.



2.

3.

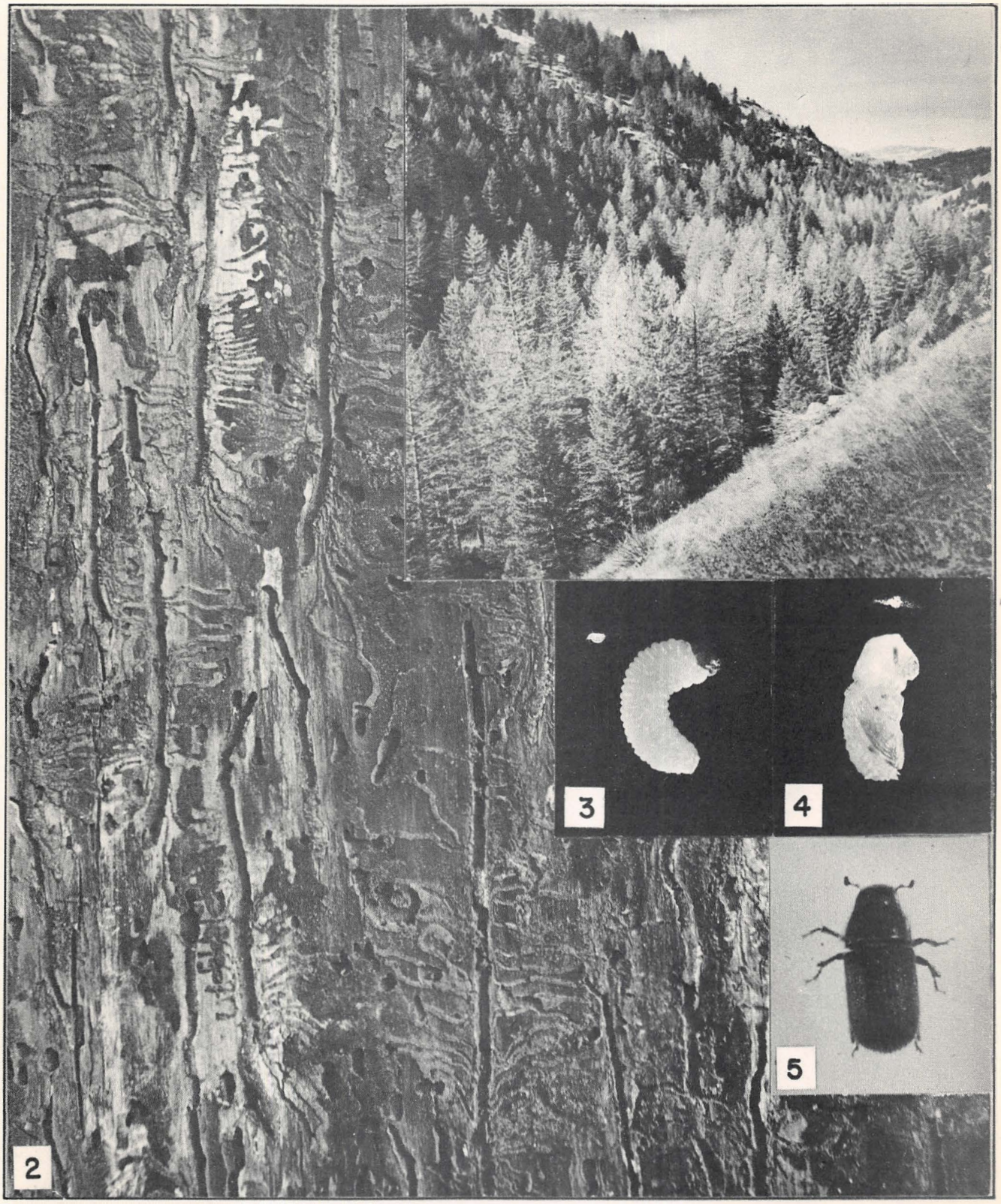
4.

1. Ponderosa pine stand showing beetle killed trees.
2. Characteristic winding egg galleries.
3. Section of bark removed to show work of adults.
4. Larvae cutting pupal cells in outer bark.

BE & PQ

DOUGLAS FIR BEETLE

Dendroctonus pseudotsugae Hopk.

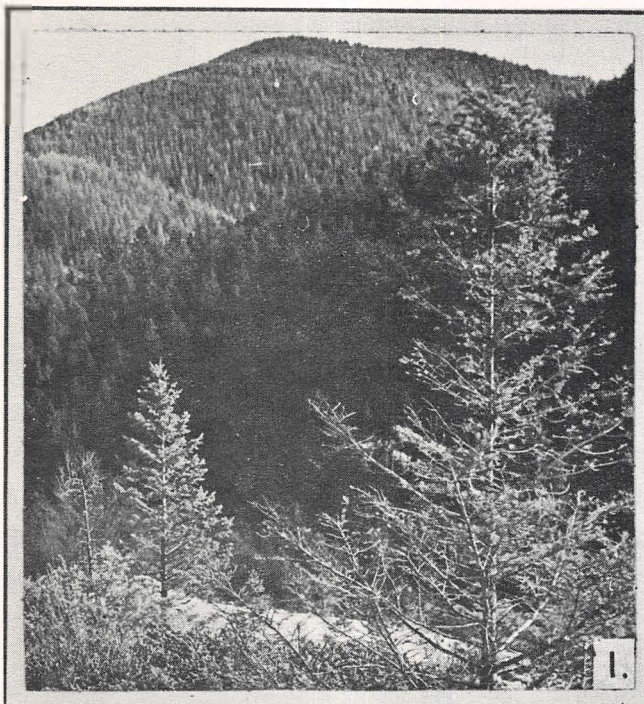


1. Douglas fir stand showing beetle killed trees.
2. Inner bark showing galleries and larval mines.
3. Larva.
4. Pupa.
5. Adult beetle.

B.E.&P.Q.

SPRUCE BUDWORM

Choristoneura fumiferana (Clem.)


1.

2.

3.

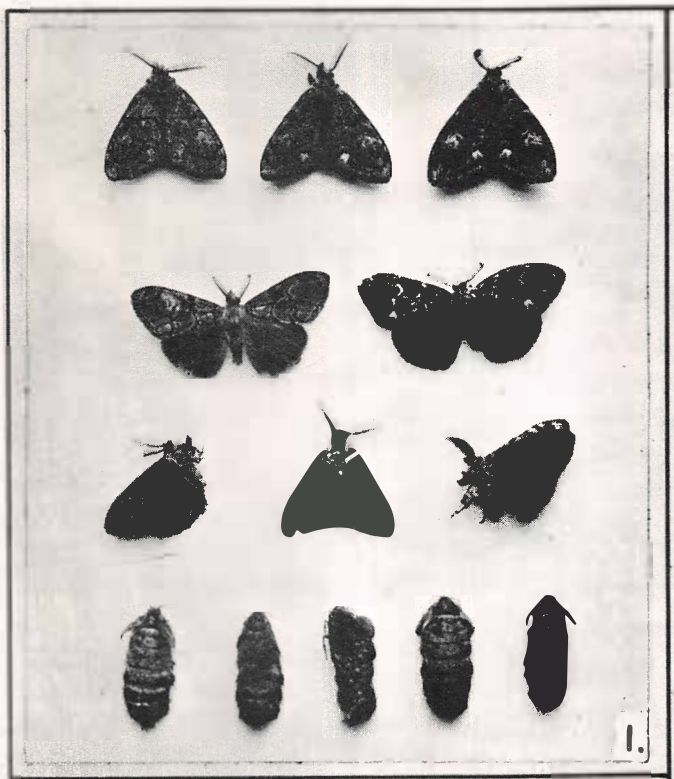
4.

1. Severly defoliated Douglas fir forest (note grayish cast).
2. Budworm defoliated tips of Douglas fir twigs.
3. Douglas fir twig showing larval webbing, pupae, and damage.
4. Larvae, pupae, empty pupal cases, and adult moths.

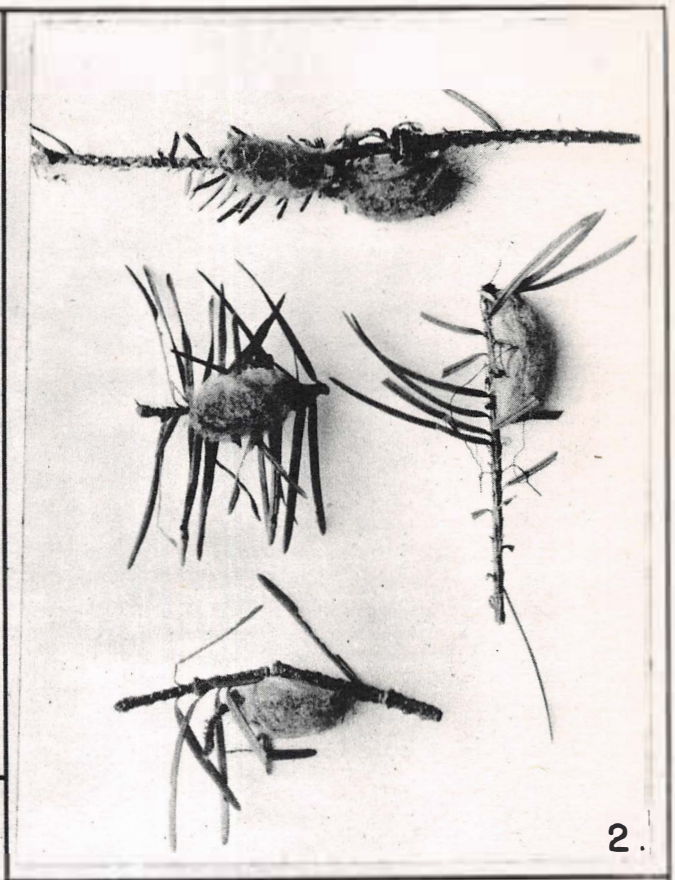
BE & PQ

DOUGLAS FIR TUSSOCK MOTH

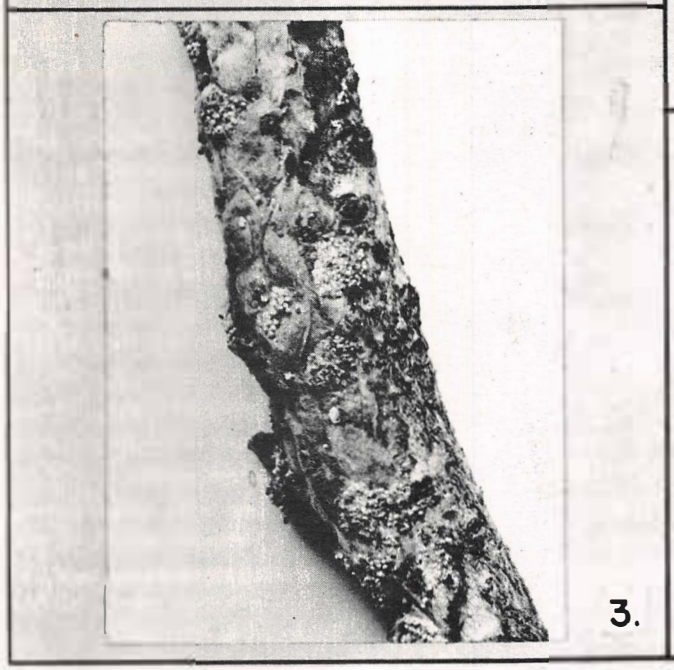
Hemerocampa pseudotsugata McD.



1.



2.



3.

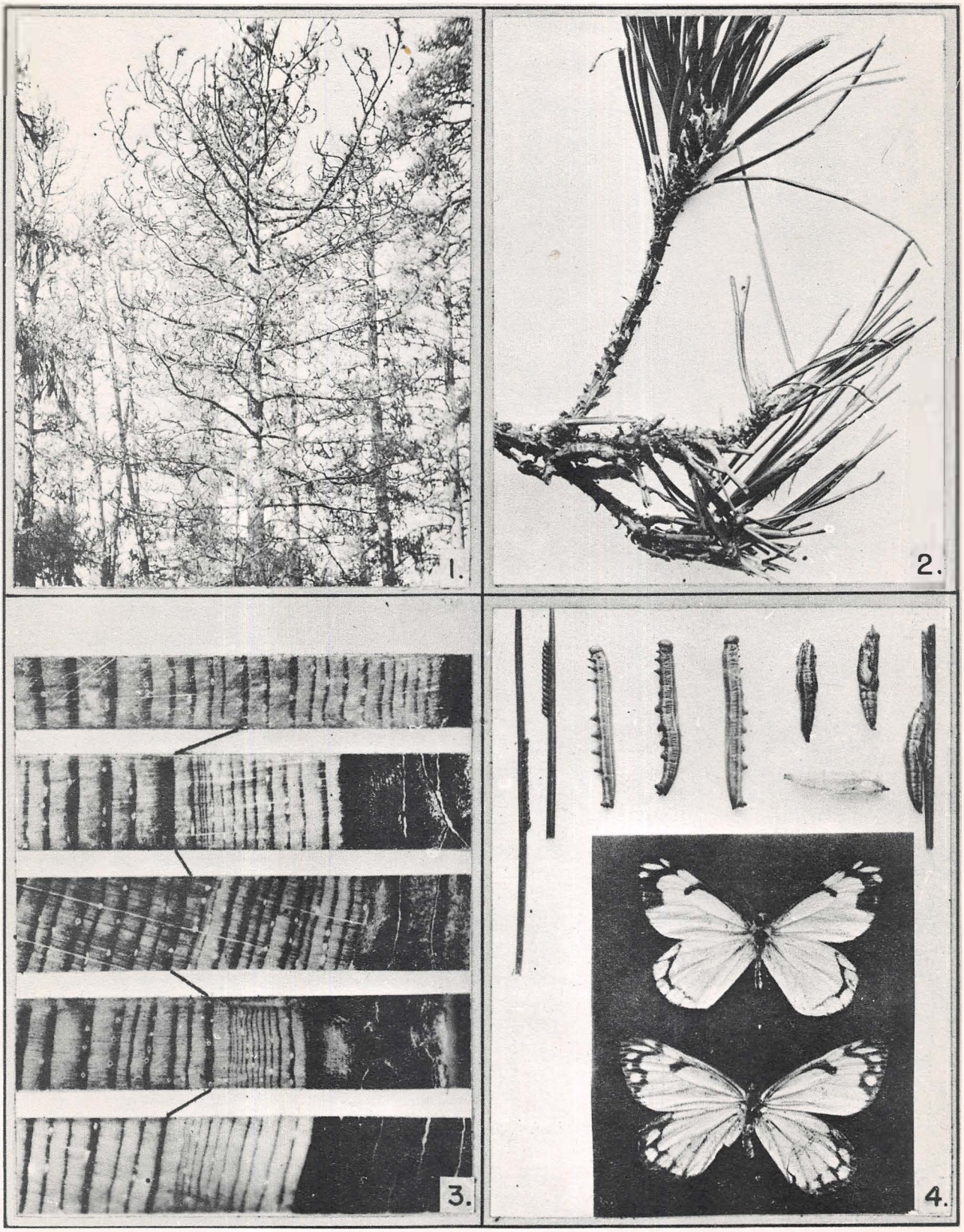
4.

1. Male (winged) and female (wingless) moths.
2. Cocoons clinging to twigs and foliage.
3. Cocoons and hatched eggs remaining on a twig.
4. Mature larvae.

Agriculture - Missoula

PINE BUTTERFLY

Neophasia menapia Feld.

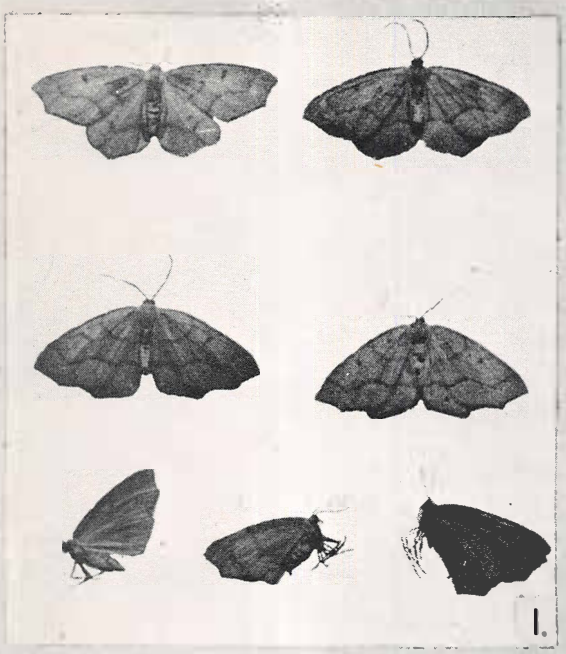


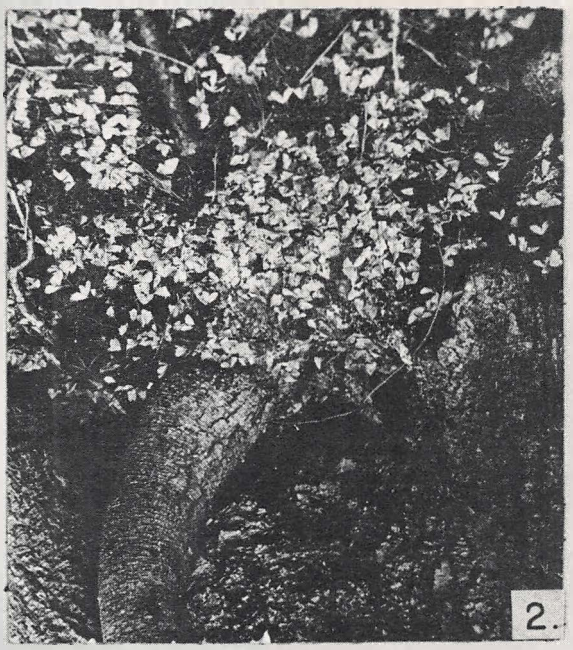
1. Defoliated ponderosa pine stand.
2. Ponderosa pine foliage, showing larval damage.
3. Effect of defoliation on annual growth (top core normal).
4. Eggs, larvae, pupae, and adult butterflies.

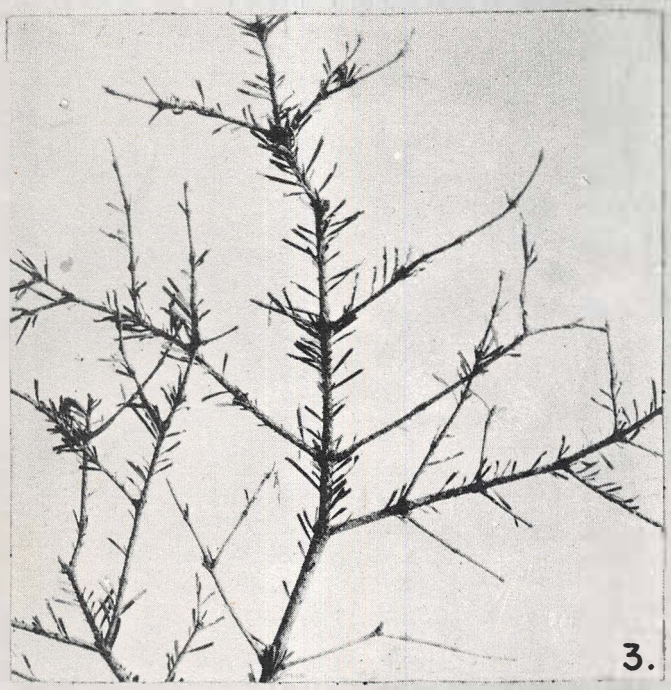
BEBPQ

HEMLOCK LOOPER

Ellopia fiscellaria var. *lugubrosa* Hulst.


1.


2.


3.

4.

1. Adult moths.
2. Mass of dead moths following a flight period.
3. Defoliated branch of alpine fir.
4. Mature larvae or "loopers."